

## FIELD OF THE INVENTION

AttyDktNo 42626/208123

computing system. Using SMBIOS, the IT department may obtain a wide variety of information concerning the computing system, such as the types of hardware, capabilities, operational status, installation date, etc. Specifically, SMBIOS includes a database of SMBIOS data structures each related to the configuration and components of the computing system. This database typically includes data concerning the computing system from port and slot configurations, processor and memory information, battery and power source indications, to even information concerning chassis configuration.

The information is typically separated into different Type structures, where each Type contains information concerning a certain aspect of the computing system.

Currently, there are 128 defined data structure Types in the SMBIOS database that describe various hardware, software, and setting of a computing system. Each Type is further divided into offsets, called Fields, where each Field provides information concerning a particular aspect of the subject component. The data in each Field of each Type may be formatted in a variety of different methods, from simple raw data values to more complex values such as bit fields that provide a wide variety of information based on the individual bit settings.

To interface with this database, SMBIOS requires the use of a utility program. The utility program receives commands from a user and based on these commands, accesses the database and retrieves and displays the desired information from the database to IT personnel. In conventional SMBIOS systems, the database typically only includes the data structures. The information for interpreting and properly displaying these data structures, on the other hand, is typically resident in the source code of the utility program. Specifically, conventional SMBIOS utility programs include all of the strings, field descriptions, bit definitions, etc. hard coded in the utility program for interpreting and displaying the data structures stored in the SMBIOS database.

As an example, the SMBIOS database includes data structure Types which are further organized into data Fields. These Fields may have raw data values indicating information such as memory speed, processor clock speed, etc. To properly display these data Fields when queried by the user, the utility program must not only retrieve the data from the database, but it must also know the data Type's structure, such as whether the current Field data is raw data, a string, bit field, etc. It must also know what format to

display the data, (e.g., decimal, binary, hexadecimal, etc.), and provide text describing the data to the user and the units in which the data is displayed.

In a conventional SMBIOS system, all of this information is typically programmed into the source code of the utility program. As such, if the utility is  
5 commanded to provide the clock speed of the processor, it will first access the SMBIOS database for this value. The utility will then use definition structures located in the utility program to determine what format the value should be displayed, (for the clock speed it would be decimal), units to display with the value, (Mhz), and text to be displayed to indicate to the user that this value represents the clock speed of the processor.

10 As with most software programs, the data structures in the SMBIOS database are frequently revised creating new versions of the database. Unfortunately, for each new version of the database, the utility program must also be updated so that data structures in the SMBIOS database can be properly interpreted and displayed. Creating different  
15 versions of the utility program is somewhat disadvantageous, as it creates yet another category of differences between individual computing systems. Some computing systems may have one version of the SMBIOS database, while others have a different version. As such, the system administrator must ensure that the proper version of the utility program is installed in the computing system to match the version of the SMBIOS database.

20 Further, the utility program also includes software code used to operate the utility that is not related to the code used in interpreting and displaying data from the SMBIOS database. As the data used for interpreting and displaying the data in the data structures of the database may be altered for different versions of the SMBIOS database, there is a risk that the non-related code may be overwritten, deleted, or otherwise corrupted during  
25 update of the utility program, thereby creating inadvertent bugs in the new version of the utility.

### SUMMARY OF THE INVENTION

The present invention provides apparatus and methods for managing the display  
30 of data stored in a SMBIOS database. The apparatus and methods of the present invention overcome many of the deficiencies described above with regard to

conventional SMBIOS programs. Specifically, the apparatus and methods of the present invention provide a template file intermediate between the utility program and database of SMBIOS. The template file includes all information required for interpreting and displaying the data structures stored in the SMBIOS database. In this regard, when the utility is commanded to retrieve and display data from the SMBIOS database, it retrieves the data from the SMBIOS database. Based on the Type and offset associated with the data, the utility program accesses the corresponding information for interpreting and displaying the data from the template file. Using this information, the utility program then properly interprets and the displays the requested information concerning the computing system.

Importantly, because the information for interpreting and displaying the data stored in the SMBIOS database is removed from the source code of the utility program and placed in the template file, updates to this information is performed in the template file, as opposed to the utility program's source code. Thus, as the SMBIOS database is updated to new versions, the utility program does not necessarily require updating. Instead, updates for interpreting and displaying can be performed in the template file and new versions of the template file created. In this regard, the utility program and all versions of the template file may be stored in the computing system. The utility program will determine the version of the SMBIOS database resident in the computing system and select the corresponding template file version to interpret and display data stored in the SMBIOS database. As such, all of the computing systems within a network will use the same version of the utility program, but their utility programs will individually select the proper version of the template file to use with the corresponding version of the SMBIOS database.

As an example, in one embodiment, the present invention provides a system management apparatus for retrieving and displaying SMBIOS data relating to the configuration and components of a computing system to a user via a display terminal. The apparatus includes a database of SMBIOS structures stored on a computer-readable medium. Each structure is divided into offsets called Fields, where each Field contains data related to a particular aspect of the configuration of the computing system or components of the computing system. Further, the apparatus includes a utility program

stored on a computer-readable medium, which in response to commands from a user, retrieves data from the SMBIOS database and displays the data on the display terminal. Importantly, the apparatus also includes a template file stored on a computer-readable medium separate from the utility. The template file contains information for interpreting and displaying the data retrieved by the utility program from the database. As such, the template file eliminates the requirement that the utility program include all of the strings, field descriptions, bit definitions, etc. for interpreting and displaying the data stored in the SMBIOS database.

With regard to the configuration of the template file, data is stored in the SMBIOS database in various manners. For example, data may be stored as raw data values, strings, free form strings, enumerated values, bit fields, or grouped bits. The information for determining the data's structure, its content, and any descriptive text associated with the data is stored in the template file. In operation, the utility program, using parsing routines and standard SMBIOS calls retrieves data from the SMBIOS database. The utility program then uses the template file to determine the structure of the data and what information the data provides, based on the Type and offset associated with the data as stored in the SMBIOS database. The utility then displays the interpreted data along with related text information to the user.

To interpret the data structures stored in the database, the template file of the present invention includes several different types of descriptor keys. These descriptor keys describe the purpose of a particular offset, or Field, in an SMBIOS data structure stored in the SMBIOS database. For example, one descriptor key referred to as DATA\_ID is used to inform the utility that the data stored in the Field and associated with the descriptor key is raw data. Examples of raw data values are clock speeds, memory speeds, handles, etc associated with the computing system. The DATA\_ID descriptor key includes information relating to the length of the data field and the format for displaying the raw data, such as hexadecimal, decimal, etc. The DATA\_ID descriptor key also includes text to accompany the data when displayed. For each raw data Field in a particular structure Type in the SMBIOS database, the template file includes a corresponding Field definition that uses the DATA\_ID descriptor key to define the structure of the offset and provide text to be displayed with the data.

In some instances, the data stored in the SMBIOS database are text strings. For this type of data, the template file of the present invention includes a descriptor key, referred to as `STRING_ID`, indicating to the utility program that the data for the current Field in the Type data structure retrieved by the utility program is a string. The

5 `STRING_ID` descriptor key, in addition to identifying the data as a string, also includes text to be displayed with the string, thereby providing additional information concerning the contents of the string. For example, if a string Field in an SMBIOS structure defines the name of the vender for the BIOS software, the template file of the present invention will include a `STRING_ID` descriptor key associated with this Type and offset in the

10 SMBIOS database. The `STRING_ID` descriptor key will indicate that the data is a string. It will also include text associated with the descriptor key such as "BIOS Vender's Name" to be displayed with the data string for the BIOS vender's name.

Bit field structures may also be used in the database, where the individual bits of the bit field represent yes/no or true/false states about, features, components, or settings

15 within the computing system. For example, associated with each bit in a bit field may be a setting for a particular component of the computing system. If the bit is set to true, then the setting is true of the component, but if set to false, it is not true. For these bit field structures, the template file of the present invention includes a `BIT_FIELD_ID` descriptor key. The `BIT_FIELD_ID` descriptor key first identifies the Field stored in the SMBIOS

20 database as a bit field and will provide parameters for interpreting the bit field. It also provides text to be printed describing the contents of the bit field, as well as text to be displayed depending on whether a bit in the bit field is a 1 or a 0. It also includes text to be displayed for each bit describing what the bit represents.

Enumerated values may also be present in the SMBIOS database, where different

25 values represent different features, components, or settings within the computing system. Specifically, one possible value of the enumerated value is one setting, while another possible value represents another setting. For this type of data structure, the template file includes a corresponding descriptor key referred to as `ENUM_ID`. The `ENUM_ID` key includes different text to be displayed based on the value of the enumerated value, such

30 that depending on the value of the enumerated value appropriate text will be displayed to the user. In this embodiment, the utility program initially retrieves the enumerated value

from the SMBIOS database, and based on its enumerated value, displays the text associated with the value as stored in the template file.

Similar to enumerated values, the SMBIOS database may also include groups of bits that collectively represent some setting of the computing system. As with

5 enumerated values, the template file includes a descriptor key  
GROUPED\_BIT\_FIELD\_ID having different text to be printed based on the settings of the grouped bits.

As mentioned, the template file of the present invention includes a descriptor key for describing a bit field, (i.e., BIT\_FIELD\_ID). In some instances, not all of the bits in  
10 an N bit field will be defined. For example, if the bit field includes 64 bits, a smaller number of these bits may be defined, while others are reserved. In this instance, so that the utility program does not needlessly process these undefined bits and the template file is not required to store information for undefined bits, the template file includes a  
15 descriptor key END\_OF\_BIT\_FIELD indicating to the utility program the last defined bit position in the bit field.

In a similar manner, an enumerated value having N possible values may have less than all N possible values defined. In this instance, the template file again includes a descriptor key END\_OF\_ENUM\_ID indicating to the utility program a last defined data value, such that the template file does not include and the utility does not search for  
20 undefined values in the template file.

As mentioned, the template file may include data in the form of groups of bits that collectively define a data value, (GROUPED\_BIT\_FIELD\_ID). For example, in a grouped bit field with M total bits a group of N bits may define  $2^N$  values because each bit can be set to either a 1 or a 0. The number of bits in the group N may be less than or  
25 equal to the total number of bits allocated (M) to the grouped bit field, and if less, other groups may be defined until all bits are used. In some embodiments, the group of bits may not have defined values for all  $2^N$  possible values. In this instance, the template file may further include a data descriptor key referred to as GBF\_END\_GROUP indicating to the utility program a last defined value for the group of bits such that the utility does not  
30 search for undefined bit field group values.

In some instances, the grouped bit field data may not define all of the bits. In this instance, the template file further includes a GBF\_END\_GROUP descriptor key. This descriptor key indicates the end of the definitions for all bit groups within the grouped bit field data.

5 In addition to descriptor keys for defining the data structures stored in the SMBIOS database, the template file of the present invention also includes structure definitions that define the structure of the template file itself. Specifically, for each data structure in the SMBIOS database, there is a corresponding structure definition in the template file that includes descriptor keys for defining the structure and text and format  
10 information related to the structure of the SMBIOS database. These structure definitions are interpreted by the utility program, which may use process control keys to properly read the data from the template file. For example, one process control key, (i.e., STRUCTURE\_HEADER\_ID), is used to indicate to the utility program the beginning of a SMBIOS structure definition in the template file and a second process control key is  
15 used to indicate the end of the template file, (i.e., END\_OF\_STRUCTURES). The STRUCTURE\_HEADER\_ID control key is used at the beginning of the definitions of each SMBIOS structure Type. Importantly, data following the STRUCTURE\_HEADER\_ID key may include control flags indicating which fields of the information stored for the Type is editable by the user, allowing the user to edit some  
20 of this information.

In some instances, one or more of the Fields in the structure definition may be repeated. Control keys SET\_REPEAT\_START\_ID and SET\_REPEAT\_END\_ID respectively mark the beginning and ending locations of repeated fields. In addition, the template file includes control keys SET\_REPEAT\_COUNT\_ID and  
25 SET\_REPEAT\_SIZE\_ID to respectively determine the number of times a group of fields in a structure definition is repeated and the size of the repeated area in bytes.

As mentioned the SMBIOS database typically includes a large amount of data concerning the computing system. For example, currently SMBIOS includes Types 00-127, which concern various hardware and software components of the system. In some  
30 instances, however, an original equipment manufacture OEM may wish to include information concerning specific additional features of their computing systems. To this



end, the present invention provides an OEM template file that includes information for interpreting and displaying the additional OEM specific data structures stored in the SMBIOS database with Types greater than or equal to 128. The information stored in the OEM template file uses the same descriptor and control keys used in the main template  
5 file discussed above.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

10 Figure 1 is an operational block diagram illustrating the use of the template file by a utility program to interpret and display data retrieved from a SMBIOS database, according to one embodiment of the present invention.

Figure 2 is an operational block diagram illustrating the steps performed by the utility program using the template file to interpret and display data retrieved from a  
15 SMBIOS database, according to one embodiment of the present invention.

### **DETAILED DESCRIPTION OF THE INVENTION**

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are  
20 shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

25 As discussed above and provided in more detail below, the present invention provides apparatus and methods for managing the display of data stored in data structures in a SMBIOS database. The apparatus and methods of the present invention provide a template file intermediate between the utility program and database of SMBIOS information. The template file includes all information required for interpreting and  
30 displaying the data structures stored in the SMBIOS database. In this regard, when the utility is commanded to retrieve and display data from the SMBIOS database, it retrieves

the data from the SMBIOS database. Based on the Type and offset associated with the data currently being processed, the utility program accesses the corresponding information for interpreting and displaying the data from the template file. Using this information, the utility program then properly interprets and the displays the requested information concerning the computing system.

Importantly, because the information for interpreting and displaying the data stored in the SMBIOS database is removed from the source code of the utility program and placed in the template file, updates to this information is performed in the template file, as opposed to the utility program. Thus, as the SMBIOS database is updated to new major and minor versions, the utility program does not require updating. Instead all updates are performed in the template file and new versions of the template file are created. In this regard, the utility program and all versions of the template file may be stored in the computing system. The utility program will determine the version of the SMBIOS database resident in the computing system and select the corresponding template file version to interpret and display data stored in the SMBIOS database. As such, all of the computing systems within a network will use the same version of the utility program, but their utility programs will individually select the proper version of the template file to use with the corresponding version of the SMBIOS database.

In some embodiments, the apparatus of the present invention may also include an OEM template file that uses the same descriptor and control keys used in the template file. The OEM template file that includes information for interpreting and displaying additional OEM specific data structures stored in the SMBIOS database.

The apparatus and methods of the present invention are used in a computing environment to provide detailed information concerning the hardware and software components of the computing system, as well as various settings. The apparatus of the present invention includes three and sometimes four separate portions that collectively perform these functions. These portions are typically embodied in program code stored in a storage device of the computer and are run by a processor. With reference to Figure 1, the computing system 12 in which the apparatus 10 of the present invention is incorporated includes a computer-readable medium typically embodied in a storage device 14. The computer readable medium includes an SMBIOS database 16 that

includes various data structures providing information concerning the various hardware and software components of the computing system. The apparatus of the present invention also includes a utility program 18 for retrieving and displaying information from the SMBIOS database based on commands from a user of the computing system.

5           Importantly, the apparatus of the present invention also includes a template file 20 intermediary between the utility program and SMBIOS database. As will be described in greater detail below, the template file includes information for interpreting the data structures stored in the SMBIOS database, as well as information for formatting the data and text to display with the data. In some embodiments, the apparatus may further  
10       include an original equipment manufacturer (OEM) template file 22 containing data for interpreting and displaying data structures added to the SMBIOS database by the OEM computing system.

          As shown by data flow arrows, 24a-24c, and the operations in Figure 2, the utility program is first commanded to retrieve data for display from the SMBIOS database 16.  
15       (See step 100). Based on this command, the utility accesses the database and retrieves the proper data. (See step 110). This data may be in one of several structured forms. Specifically, the data may be a raw data value, a string, a bit field, etc. To properly interpret the data structure, the utility program, using the Type and offset of the data as stored in the database, accesses the portion of the template file or OEM template file  
20       containing information corresponding to the Type and offset. (See step 120). Using the information stored in the template file, the utility program determines the information in the data structure and any formatting for displaying the data. (See step 130). The utility program then displays the data, along with any accompanying text associated with the data to a display of the computing system and awaits a new command. (See step 140).  
25       Note that the template file includes structure definitions for Types 000-127 and the OEM template file include structure definitions for Types 128-255. Based on the Type associated with the data retrieved from the SMBIOS database, the utility program will access the appropriate template file.

          As illustrated in Figure 1, the present invention provides several advantages over  
30       conventional SMBIOS systems. Specifically, all of the information for interpreting and displaying data stored in data structures of the SMBIOS database is removed from the

source code of the utility program and placed in a separate template file. In this way, the data may be easily updated by merely updating the template file, as opposed to revising the utility program. Further, and importantly, because all revisions are made to the template file, a common utility program may be used for various versions of the SMBIOS database. In this regard, all possible versions of the template file corresponding to all versions of the SMBIOS database may be stored along with the utility program in the storage device of the computing system. The utility program will access the SMBIOS database in the system and determine its version. The utility program will then select the corresponding version of the template file for interpreting and displaying the data it retrieves from the SMBIOS database.

The discussion below make reference to a utility program used for retrieving and displaying data from the SMBIOS database. It further discusses interaction of the utility program with the template and OEM template file. An example of a utility program for this purpose has been developed by American Megatrends, Inc. (AMI) who is the assignee of the present application. This program is referred to in the market as SMBINFO™ and is commercially available through AMI. The SMBINFO utility program is specifically designed to operate in conjunction with the template and OEM template files to retrieve and display information stored in the SMBIOS database.

Described in detail below is the use of different descriptor and control keys in the construction of the template file and OEM template file. These keys are used to describe the various data structures stored in the SMBIOS database and provide format and text information for display of the data. The creation of data for each structure Type and field of the SMBIOS database is not illustrated below for sake of brevity. Instead, demonstrations of the use of each of the descriptor and control keys with selected data structures in the SMBIOS database will instruct one skilled in the art in creating the entire template file.

As discussed above, the SMBIOS database includes various data stored in different data structure Types defining various hardware and software settings of the computing system. The details concerning SMBIOS in general and the specifics concerning the utility program and SMBIOS database are disclosed in "System Management BIOS Reference Specification," version 2.3 (August 12, 1998) authored by

American Megatrends, Inc. et al. (hereinafter "SMBIOS Specification"). The contents of this document are incorporated herein by reference. With regard to the SMBIOS Specification, the SMBIOS database includes data structures separated into 128 Types that include data concerning everything from the system BIOS used by the computing device, the processor, memory, chassis, ports, slots, etc, of the computing system. Within each structure Type there is various data related to the subject of the Type designated by data Fields.

For example, a Type 0 structure includes data related to the BIOS of the computing system. Stored in this structure is information concerning the vendor of the BIOS, the version of BIOS, BIOS starting address, BIOS characteristics, etc. Each piece of information is stored within the structure in different Fields. Further, each Field may be stored as different data types. Specifically, the vendor's name and BIOS version are stored as strings in the database, while BIOS characteristics, which indicates all the various characteristics of the BIOS, is stored as a bit field. For each structure Type and each of its Fields, the template file of the present invention includes data descriptor keys and information for interpreting and displaying the information. The structure of the template file and OEM template file is described below.

There are two main parts of the template file: the Main header and the data body. Note that the OEM template does not include a Main header; it only includes the data body portion. The Main header is organized as shown in Table 1:

Table 1 – Main Template File Header			
Offset	Size	Type	Description
00	dd	Signature	SMBIOS Data Signature (4 bytes)
04	dd	Version	DWORD version
08	db	Control Flag	Control Flag (1 byte) Bit 0: 0-editable fields displayed Bit 1: editable fields enabled
09	db	Checksum	8 bit checksum byte

It includes information concerning the version, editable fields within the template file, and a checksum.

Following the header, is the body of the template file. The OEM template file includes only the body and not the Main header. The body of the template file includes

structure definitions for Types 000-127 and the OEM template file may include structure definitions for Types 128-255. The body includes all of the information for interpreting and displaying each Field of each data structure stored in the SMBIOS database.

Specifically, for each Field of each data structure type in SMBIOS, there is a

- 5 corresponding Field definition in the template file for interpreting and displaying that Field . Each structure definition in the template file is preceded by its own structure header that contains information about the structure's type, its title, which offsets are editable in the structure, and a pointer to the start of the descriptor keys. The structure definition header is organized as shown in Table 2:

10

Table 2 – Template Structure Header			
Offset	Size	Type	Description
00	dw	Structure Header ID	Special processing key that identifies the start of a new structure definition
02	db	Type	Type of SMBIOS structure
03	dw	Pointer to Title	Offset to the structure's title string
05	dw	Pointer to Editable Offset List	Offset to a null terminated list of editable offsets in the structure
07	dw	Pointer to the Start of Data	Offset to the Start of the Structure Definition Data

Following the structure header is the information for interpreting and displaying the data structures of the SMBIOS database. This information is typically in the form of descriptor keys for describing the data structure and control keys, which are used to

15 navigate the structure definition. The data descriptor keys and control keys are listed below in Tables 3 and 4:

Table 3 - Descriptor Keys	
Key	Description
DATA_ID	used to describe all types of raw data
STRING_ID	used to describe strings
BIT_FIELD_ID	used to describe bit values and their settings
ENUM_ID	used to describe enumerated values and their settings
GROUPED_BIT_FIELD_ID	used to describe groups of bits that exist within a larger data type
FREEFORM_STRINGS_ID	used to describe free-form string data

Table 4 - Control Keys	
Key	Description
STRUCTURE_HEADER_ID	used to mark the start of a new SMBIOS structure definition
ENDOF_STRUCTURES	used to mark the end of the template file
SET_REPEAT_COUNT_ID	used to indicate that the utility program needs to calculate the number of times a group of fields are to be repeated
SET_REPEAT_SIZE	used to indicate that the utility program needs to calculate the total size of the group of fields that are repeated
SET_REPEAT_START_ID	used to mark the starting location for a group of repeated fields
SET_REPEAT_END_ID	used to mark the ending location for a group of repeated fields

Each of the descriptor keys and control keys is described below. The description below is used to illustrate how these keys may be used to construct individual structure definitions for each offset of each Type data structure stored in the SMBIOS database. The keys are described in conjunction with specific data structures from the SMBIOS database to provide examples of their use. These examples can be used to construct structure definitions for the remaining data of the SMBIOS database. For example, below is illustrated use of the DATA\_ID descriptor key to create a structure definition for a data value stored in the SMBIOS database indicating the speed of an internal clock. This example can be used to create structure definitions in the template file and OEM template file for all other data values stored in the SMBIOS database.

#### I. Data Descriptor Keys

Each data descriptor key is described below. For each key, the following information is provided: a description of the key, the encoded value designating the key, any sub-keys, and an example of use of the key.

##### A. DATA\_ID

The DATA\_ID descriptor key is used for fields that consist of some raw data value. Examples of raw data stored in the SMBIOS database include memory speed, processor clock, handle numbers, etc. As many raw data values are given in terms of a

unit value, the DATA\_ID key also includes text to be printed with the raw data indicating the units of the value, such as “Mhz,” “ns,” “hex,” etc.

Encoded Value: 0xFFFF0

Format

- 5 The format for the DATA\_ID descriptor key includes a field title describing the data, length of the data in bytes, format of the data, text to be printed with the data, and a field description.

- 10 dw DATA\_ID  
db Null terminated string for field title  
db Length of data field in bytes  
db Format ID  
db Null terminated string which follows the printed numeric data value  
db Null terminated string for field description

- 15 Notes:

- The Format ID is a special indicator flag that specifies how the data is to be printed. It may also be used in cases where the data needs to have some formula applied to it to derive a meaningful value to display to the user. If a formula is used, the formula is typically coded in the utility program. Table 5 lists the current codes for the format of the data. It must be understood that additional formats could be created depending on the type of raw data to be retrieved and displayed.

Table 5		
Format Code	Encoded Value	Notes
FORMAT_SEE_DETAILS	0	Prints a message for the user to see a details window for more information
FORMAT_HEX	1	Prints the data in hexadecimal
FORMAT_DECIMAL	2	Prints the data in decimal
FORMAT_BIOS_ROMSIZE	3	Prints the data according to the formula $64k \cdot (n+1)$ .
FORMAT_2_TO_N	4	Prints the data according to the formula $2^n$ . Used for memory size.
FORMAT_EXTENDED_DATA	5	Format used for extra data that may exist which has no specific (or known) definition. An example would be any undefined extension bytes at the end of Type 0 or the variable SMBIOS specification). Extended data is generally used



Table 5		
Format Code	Encoded Value	Notes
		within a repeat loop, therefore, when encountering this key type the utility program prints "Extended Value Data Number:" followed by the current iteration of the loop.
FORMAT_MEMORY_CAPACITY	6	Prints "Unknown Capacity" the value is 8000000h, or the value in kB.

#### Assembler Example:

Below is an example of the Field definition for the speed of the external clock, which is Type 4, offset 12h in the SMBIOS database.

```

5      dw    DATA_ID                ; Data identifier
      db    "External Clock",0        ; Field description
      db    02h                      ; Length of data in bytes
      db    FORMAT_DECIMAL           ; Printed data format
      db    "Mhz",0                  ; Any text to follow data
10     db    "Clock frequency of the external clock (in Mhz)",0 ; Field description

```

#### **B. STRING\_ID**

The STRING\_ID descriptor key is used for fields that consist of strings and informs the utility program that this offset represents the number of a string stored in the SMBIOS database.

Encoded Value:      0xFFFF1

#### Format

The format for the STRING\_ID descriptor key includes a field title describing the data, text to be printed with the data, and field description.

```

20     dw    STRING_ID
      db    Null terminated string for field title
      db    Null terminated string for field description

```

#### Assembler Example:

Below is an example of the structure definition for the vendor name of the BIOS software used in the computing system, which is Type 0, offset 04h in the SMBIOS database.

```

dw    STRING_ID                ; String identifier
db    "BIOS Vendor's Name",0   ; Field description
db    "String indicating the name of the BIOS vendor",0 ; Field description

```

## 5 C. BIT\_FIELD\_ID and END\_OF\_BIT\_FIELD\_ID

These descriptor keys define a bit field. A bit field is a data value whose individual bits represent one of two possible states. The BIT\_FIELD\_ID key begins description of each bit in the field and provides appropriate text to be printed based on whether the individual bits are 1 or 0. The END\_OF\_BIT\_FIELD\_ID key indicates the

10 end of the bit definitions, so that not all bits within the bit field have to be defined in the template file. For example, if the byte size is 2, but bits 11-15 are reserved or undefined, their definitions can be left out of the template file.

### Encoded Value:

```

15 BIT_FIELD_ID                0xFFFF2
    END_OF_BIT_FIELD_ID      0xFFFF3

```

### Format

The format for the BIT\_FIELD\_ID descriptor key includes a field title describing the data, size in bytes of the bit field data value, text to display based on whether the bits

20 are a 1 or a 0, the number of each bit in the bit field and a description for each bit.

```

dw    BIT_FIELD_ID
db    Null terminated string for field title
db    Size in bytes of the bit field data value
db    Null terminated string to use when bit = 0
25 db    Null terminated string to use when bit = 1
    db    xx - Bit Field bit number
    db    Null terminated string describing the previous bit number
    . . . repeat this section until all bits are defined . . .
    dw    END_OF_BIT_FIELD_ID

```

### Assembler Example:

Below is an example of use of these keys to create a structure definition for the bit field stored in the SMBIOS database describing the error correcting capabilities of the memory controller of the computing system. This information is Type 5, offset 05h in

35 the SMBIOS database. The bit field for this information consists of six (6) bits, where

each bit defines an error correcting capability based on whether the bit is set to 1 or 0. The meaning of each bit is provided in Table 6.

<b>Byte Bit Position</b>	<b>Meaning</b>
Bit 0	Other
Bit 1	Unknown
Bit 2	None
Bit 3	Single Bit Error Correcting
Bit 4	Double Bit Error Correcting
Bit 5	Error Scrubbing

5	dw	BIT_FIELD_ID	; Data identifier
	db	“Error Correcting Capability”,0	; Field description
	db	1	; Bytes used for bit-field
	db	“No”,0	; String to use when bit = 0
	db	“Yes”,0	; String to use when bit = 1
10	; Begin bit field encoding for this value		
	db	00h, “Other”,0	
	db	01h, “Unknown”,0	
	db	02h, “None”,0	
	db	03h, “Single Bit Error Correcting”,0	
15	db	04h, “Double Bit Error Correcting”,0	
	db	05h, “Error Scrubbing”,0	
	dw	ENDOF BIT FIELD ID	

#### D. ENUM ID and ENDOF ENUM ID

Encoded Value:

Format:

5     dw    ENUM\_ID  
       db    Null terminated string for field title  
       db    xx – Enumerated value setting  
       db    Null terminated string describing the previous enumerated value  
       ...repeat this section until all values are defined...  
       dw    ENDOF\_ENUM\_ID

Notes:

10     The ENDOF\_ENUM\_ID key indicates the end of the enumerated values so that undefined values do not have to be defined in the template file. For example, an enumerated value stored in the SMBIOS database is on byte long or 8 bits. That means that there are 2<sup>8</sup> possible values. If less than all values are currently defined, the ENDOF\_ENUM\_ID may be used after the last defined value.

15

Assembler Data Example:

20     Illustrated below is the structure definition for data related to the processor type, which is Type 4, offset 05h. The enumerated value for the offset has 6 possible values, with each value of the enumerated value indicating a different type of processor. Table 7 provides the processor designation for each byte value of the enumerate value.

Table 7	
Byte Value	Meaning
01h	Other
02h	Unknown
03h	Central Processor
04h	Math Processor
05h	DSP Processor
06h	Video Processor

25     dw    ENUM\_ID                             ; Data identifier  
       db    "Processor Type",0               ; Field Description  
       db    01h, "Other",0  
       db    02h, "Unknown",0  
       db    03h, "Central Processor",0  
       db    04h, "Math Processor",0  
       db    05h, "DSP Processor",0  
30     db    06h, "Video Processor",0  
       dw    ENDOF\_ENUM\_ID

**E. GROUPED\_BIT\_FIELD\_ID, GBF\_END\_GROUP, and  
ENDOF\_GROUPED\_BIT\_FIELD\_ID**

These descriptor keys define a grouped bit field. A grouped bit field differs from a normal bit field in that the groups of bits collectively represent some sort of setting of the computing system similar to an enumerated value. For example, a grouped bit field having a size of 1 byte may have bits 0-2 representing 8 different settings based on their value, while bits 3 and 4 represent 4 other settings, etc. In this instance, the GROUPED\_BIT\_FIELD\_ID descriptor key represents the beginning of the grouped bit field. The GBF\_END\_GROUP descriptor key indicates the end of the definitions for each group within the grouped bit field. Similar to an enumerated value, each group within the grouped bit field contains description strings for each possible value of the bit group. Finally, since the number of possible values per group is defined as  $2^n$  (where n is the number of bits in the group), all possible values may not be defined. As such, the ENDOF\_GROUPED\_BIT\_FIELD\_ID indicates the end of the grouped bit definitions, so that undefined groups of bits do not have to be defined in the template file. For example, if the byte size is 1, but only one bit group from bits 3:0 is defined, the remaining bit groups do not have to be defined in the template file.

Encoded Value:

	GROUPED_BIT_FIELD_ID	0xFFFF6
20	GBF_END_GROUP	0xFFFF7
	ENDOF_GROUPED_BIT_FIELD_ID	0xFFFF8

Format

25	dw	GROUPED_BIT_FIELD_ID
	db	Null terminated string for field title
	db	Number of bytes occupied by the grouped bit field
	→	(Begin bit field group encoding)
	db	Group start bit
	db	Group end bit
30	db	Null terminated string of group description
	→	db Bit group value
	db	Null terminated string describing the above value
		... repeat this section for each possible value in the group ...
	db	GBF_END_GROUP
35		... repeat this section for all groups ...
	dw	ENDOF_GROUPED_BIT_FIELD_ID

### Assembler Example:

The following is an example of the structure definition related to CPU status information concerning the CPU of the computing system. This structure definition is Type 4, offset 18h in the SMBIOS database and includes two grouped bit fields as a subset of a larger data structure, with bit 6 being a one bit grouped field and bits 2:0 representing the other grouped bit field. Specifically, bit 7 and bits 5:3 are reserved, while bit 6 is a first grouped bit field and bits 2:0 is a second grouped bit field. This is illustrated in Table 8.

Table 8	
Bits	Description
7	Reserved, must be 0
6	CPU Socket Populated 1 - CPU Socket Populated 2 - CPU Socket Unpopulated
5:3	Reserved, must be 0
2:0	CPU Status 0h - Unknown 1h - CPU Enabled 2h - CPU Disabled by User via BIOS Setup 3h - CPU Disabled by BIOS (Post Error) 4h - CPU is Idle, waiting to be enabled 5-6h - Reserved 7h -Other

```
10      dw    GROUPED_BIT_FIELD_ID      ; Data identifier
      db    "Status",0                  ; Field Description
      db    1                          ; Number of bytes occupied
      ; begin bit field encoding for this value
      db    6,6                        ; First group (start, end) bits
15      db    "CPU Socket Populated,"0  ; Group title
      db    00h, "No",0                ; Group values . . .
      db    01h, "Yes",0
      dw    GBF_END_GROUP               ; Signal end of this group
      db    2,0                        ; Next group (start, end) bits
20      db    "CPU Status,"0            ; Group title
      db    00h, "Unknown",0           ; Group values . . .
      db    01h, "CPU Enabled",0
      db    02h, "CPU Disabled by User (via setup)",0
      db    03h, "CPU Disabled by BIOS (Post Error)",0
```

db 04h. "CPU is Idle (waiting to be enabled)",0  
db 07h. "Other",0  
dw GBF\_END\_GROUP ; Signal end of this group  
dw END\_OF\_GROUPED\_BIT\_FIELD\_ID ; Signal end of grouped bit field

5

## F. FREEFORM\_STRINGS\_ID

The FREEFORM\_STRING\_ID descriptor key is used to indicate that the field is a count for free-form strings at the end of the structure, such as Type 11 (OEM Strings)

10 or Type 12 (System Configuration Options).

Encoded Value: 0xFFFF9

### Format

dw FREEFORM\_STRINGS\_ID  
db Null terminated string describing the above value

15

### Notes:

Currently, there are only two structure types that use the FREEFORM\_STRINGS\_ID descriptor key, and essentially this key is the only entry in their structure definitions. When the utility program encounters this key, it knows that this byte offset within the SMBIOS structure represents the number of free-form strings.

20

### Assembler Example:

dw FREEFORM\_STRINGS\_ID  
db "Free-form strings: OEM Strings",0

## 25 II. Process Control Keys

Each process control key is described below. For each key, the following information is provided: a description of the key, the encoded value designating the key, any sub-keys, and an example of use of the key. These keys are used to direct the utility program when retrieving information from structure definitions stored in the template

30 file.

### A. STRUCTURE\_HEADER\_ID

The STRUCTURE\_HEADER\_ID is a control key used to indicate the beginning of a structure definition. This key is used to indicate when the data begins and ends. For example, at the beginning of the structure definition in the template file, the

STRUCTURE\_HEADER\_ID is used to designate the beginning of the structure definition.

Encoded Value: 0xFFE0

Format

5 dw STRUCTURE\_HEADER\_ID  
(followed by structure header data, i.e., Type, Pointer to Title, etc.)

Assembler Example:

The following example illustrates the beginning portion of the structure definition  
10 in the template file for Type 0 SMBIOS database structures.

```

;-----;
;Type 0 Structure Definition
;-----;
15 dw  STRUCTURE_HEADER_ID          ; Start of structure identifier
   BIOS_INFOstart:
   db  BIOS_INFO                  ; TYPE
   dw  offset BIOS_INFOstring-offset BIOS_INFOstart
   dw  offset BIOS_INFOfields-offset BIOS_INFOstart
   dw  offset BIOS_INFodata-offset BIOS_INFOstart
20 BIOS_INFOstring:
   db  "BIOS Information",0        ; Title string
   BIOS_INFOfields:
   db  05h, 08h, 09h, 00h         ; Editable field offsets inside fixed header
   BIOS_INFodata:
25 ;-----;
   dw  STRING_ID                  ; STRING identifier
   db  "BIOS Vendor's Name",0     ; Field Description
   db  "String indicating the name of the BIOS vendor.",0 ; Field Description

```

30 **B. END\_OF\_STRUCTURES**

The END\_OF\_STRUCTURES key is a control key used to indicate the end of the template file.

Encoded Value: 0xFFE1

35 Format:

dw END\_OF\_STRUCTURES



### Assembler Example:

At the very end of the template file the following is placed:

5           ;-----;  
dw    ENDOF\_STRUCTURES

### **C. SET\_REPEAT\_COUNT\_ID**

This control key is used to indicate the beginning of a repeating loop in the structure definition. When encountering this key, the utility program uses the value following the key (Repeat Type) to know how to determine the repeat count.

Encoded Value:       0xFFE2

#### Format:

15           dw    SET\_REPEAT\_COUNT\_ID  
             dw    Repeat count type  
             db    Size of repeated section in bytes (RepeatSize)  
20           db    Number of non-repeating bytes that follow the repeated block

#### Repeat Count Types:

0: GET\_COUNT\_FROM\_FOLLOWING\_OFFSET  
1: GET\_COUNT\_FROM\_LENGTH

#### Notes:

- 25           1. If Repeat Count is of the type GET\_COUNT\_FROM\_FOLLOWING  
              \_OFFSET, then the utility program gets the explicit count from the next offset  
              in the SMBIOS structure.
- 30           2. If Repeat Count is of the type GET\_COUNT\_FROM\_LENGTH, the utility  
              program determines the count based on the overall length of the structure and  
              the size of the repeat block.
3. If the utility program has processed a SET\_REPEAT\_SIZE\_ID, then that size  
              will be used in the count calculation.
- 35           4. If the utility program has not encountered a SET\_REPEAT\_SIZE\_ID key, then  
              the repeat size will be determined from the 'RepeatSize' value in the Format  
              header.
5. If RepeatSize is set to 0, then the SET\_REPEAT\_SIZE\_ID key must be used  
              before beginning the loop.

40   The count calculation for GET\_COUNT\_FROM\_LENGTH is as follows:

$$\frac{(\text{Structure Length} - \text{Current offset in the structure} - \text{Number of non-repeating bytes})}{\text{RepeatSize}}$$

Assembler Example:

This section of code is from Memory Controller Information, Type 5, offset 0Fh.

- A listing of the Type 5 structure is illustrated in Table 9, (offsets 00h - 0Dh are not illustrated). Note that the number of non-repeating bytes is 1 because of the bit field following the Memory Module Configuration Handle repeat block.

Table 9				
Offset	Name	Length	Value	Description
0Eh	Number of Associated Memory Slots (x)	BYTE	Varies	Defines how many of the Memory Module Information blocks are controlled by this controller
0Fh to (0Fh + (2*x) - 1)	Memory Module Configuration Handles	x WORD	Varies	A list of memory information structure handles controlled by this controller. Value in offset 0Eh (x) defines the count
0Fh + (2*x)	Enabled Error Correcting Capabilities	BYTE	Bit Field	Identifies the error-correcting capabilities that were enabled when the structure was built.

In this instance, the offset 0Eh provides the number of times the looped information will be repeated. Below illustrates use of the

- GET\_COUNT\_FROM\_FOLLOWING\_OFFSET to get the count from the offset 0Eh and use of the SET\_REPEAT\_COUNT\_ID, SET\_REPEAT\_START\_ID, and SET\_REPEAT\_END\_ID keys.

```
..
..
15  ..
    dw  SET_REPEAT_COUNT_ID          ; Set REPEAT identifier.
    db  GET_COUNT_FROM_FOLLOWING_OFFSET; Get repeat count from
                                           next offset
    db  2                            ; Size of repeated section in bytes
20  db  1                            ; Number of non-repeating bytes

    dw  DATA_ID                    ; Data identifier
    db  "Number of Associated Memory Slots",0 ; Field Description
    db  01h                         ; Length of data
25  db  FORMAT_DECIMAL              ; Printed Data format
    db  " Slots",0                  ; Any text to follow data
    db  "Number of memory module slots controlled by this controller",0
```

```

; -----Repeating block start
dw    SET_REPEAT_START_ID
dw    DATA_ID                ; Data identifier
db    "Memory Module Configuration Handle",0 ; Field Description
5     db    02h                ; Length of data
db    FORMAT_HEX              ; Printed Data format
db    "h",0                   ; Any text to follow data
db    "Handle of a memory module controlled by this controller",0

10    dw    SET_REPEAT_END_ID
; -----Repeating block end

dw    BIT_FIELD_ID            ; Data identifier
db    "Enabled Error Correcting Capabilities",0 ; Field Description
15    db    1                  ; Bytes used for bit field
db    "No",0                   ; String to use when bit = 0
db    "Yes!",0                 ; String to use when bit = 1
; Begin bit field encoding for this value
db    00h, "Other",0
20    db    01h, "Unknown",0
db    02h, "None",0
db    03h, "Single Bit Error Correcting",0
db    04h, "Double Bit Error Correcting",0
db    05h, "Error Scrubbing",0
25    dw    END_OF_BIT_FIELD_ID

```

#### **D. SET\_REPEAT\_SIZE\_ID**

Used to indicate the size of a repeated block of fields in the structure definition when the repeat size is actually specified by a Field value in the structure data, rather than being given in the SET\_REPEAT\_COUNT\_ID information. When encountering this key, the utility program uses the following byte in the SMBIOS structure to know how to determine the repeat count.

```

35    Encoded Value:      0xFFE3

      Format:

dw    SET_REPEAT_SIZE_ID

```

Notes:

1. If the utility program has already processed a SET\_REPEAT\_COUNT\_ID and the repeat block size in the header is nonzero, then the repeat count has already been set and this key will be ignored.
2. If the utility program has NOT encountered a SET\_REPEAT\_COUNT\_ID key, or the repeat block size in the SET\_REPEAT\_COUNT\_ID header is 0, then the byte at this position in the SMBIOS structure will be used as the size and the repeat count will be calculated as follows:

$$\frac{(\text{Structure Length} - \text{Current offset in the structure} - \text{Number of non-repeating bytes})}{\text{RepeatSize}}$$

whereas “Number of nonrepeating bytes” is set to 0 by default.

Assembler Data Example:

This section of code is from System Event Log Type 15. A listing of the Type structure is illustrated in Table 10, (offsets 02h - 14h are not illustrated).

Table 10				
Offset	Name	Length	Value	Description
00h	Type	BYTE	15	Event Log Type Indicator
01h	Length	BYTE	Varies	Length of the structure, including the Type and Length fields. The Length is 14h for v2.0 implementations or computed by the BIOS as 17h + (x*y) for v2.1 and higher—where x is the value present at offset 15h and y is the value present at offset 16h
...	...	...	...	...
15h	Number of Supported Log Type Descriptors (x)	BYTE	Varies	Number of supported even log type descriptors that follow. If the value is 0, the list that starts at offset 17h is not present
16h	Length of each Log Type Descriptor (y)	BYTE	2	Identifies the number of bytes associated with each type entry in the list below. The value is currently “hard-coded” as 2, since each entry consists of two bytes. This field’s presence allows future additions to the type list. Software that interprets the following list should not assume a list entry’s

Table 10				
Offset	Name	Length	Value	Description
				length.
17h to (17h + (x*y)) - 1	List of Supported Event Log Type Descriptors	Varies	Varies	Contains a list of Event Log Type Descriptors (see 3.3.16.1), so long as the value specified in offset 15h is non-zero.

Table 11 shows the description for different Event Log values.

Table 11	
Value	Description
00h	Reserved
01h	Single-bit ECC memory error
02h	Multi-bit ECC memory error
03h	Parity memory error
04h	Bus time-out
05h	I/O Channel Check
06h	Software NMI
07h	POST Memory Resize
08h	POST Error
09h	PCI Parity Error
0Ah	PCI System Error
0Bh	CPU Failure
0Ch	EISA FailSafe Timer time-out
0Dh	Correctable memory log disabled
0Eh	Logging disabled for a specific Event Type - too many errors
0Fh	Reserved
10h	System Limit Exceeded (e.g. voltage or temperature threshold exceeded)
11h	CPU Failure Asynchronous hardware timer expired and issued a system reset
12h	System configuration information
13h	Hard-disk information
14h	System reconfigured
15h	Uncorrectable CPU-complex error
16h	Log Area Reset/Cleared
17h	System boot

```

..
..
5      dw    SET_REPEAT_COUNT_ID          ; Set REPEAT identifier.
      db    GET_COUNT_FROM_FOLLOWING_OFFSET ;Get repeat count from
                                           next key
      db    0                               ; Size of repeated section in bytes
10     db    0                               ; Number of non-repeating bytes

```

	dw	DATA_ID	; Data identifier
	db	"Number of Supported Log Type Descriptors",0 ; Field Description	
	db	01h	; Length of data
5	db	FORMAT_DECIMAL	; Printed Data format
	db	" Descriptors",0	; Any text to follow data
	db	"Number of the supported event log type descriptors that follow.",0	
10	dw	SET_REPEAT_SIZE_ID	
	dw	DATA_ID	; Data identifier
	db	"Length of each Log Type Descriptor",0 ; Field Description	
	db	01h	; Length of data
	db	FORMAT_DECIMAL	; Printed Data format
15	db	" Bytes",0	; Any text to follow data
	db	"Identifies the number of bytes associated with each type entry.",0	
		; -----Repeating block start	
20	dw	SET_REPEAT_START_ID	
	dw	ENUM_ID	
	db	"Log Type",0	
	db	00h, "Reserved.",0	
25	db	01h, "Single-bit ECC memory error",0	
	db	02h, "Multi-bit ECC memory error",0	
	db	03h, "Parity memory error",0	
	db	04h, "Bus time-out",0	
	db	05h, "I/O Channel Check",0	
	db	06h, "Software NMI",0	
30	db	07h, "POST Memory Resize",0	
	db	08h, "POST Error",0	
	db	09h, "PCI Parity Error",0	
	db	0Ah, "PCI System Error",0	
	db	0Bh, "CPU Failure",0	
35	db	0Ch, "EISA FailSafe Timer time-out",0	
	db	0Dh, "Correctable memory log disabled",0	
	db	0Eh, "Logging disabled for a specific Event Type - too many errors ",0	
	db	0Fh, "Reserved",0	
40	db	10h, "System Limit Exceeded (e.g. voltage or temperature threshold exceeded).",0	
	db	11h, "Asynchronous hardware timer expired and issued a system reset.",0	
	db	12h, "System configuration information",0	
	db	13h, "Hard-disk information",0	
	db	14h, "System reconfigured",0	
45	db	15h, "Uncorrectable CPU-complex error",0	
	db	16h, "Log Area Reset/Cleared",0	

```

db      17h, "System boot",0
dw      END_OF_ENUM_ID

5      dw      ENUM_ID
db      "Variable Data Format Type",0
db      00h,"None",0
db      01h,"Handle",0
db      02h,"Multiple-Event",0
db      03h,"Multiple-Event Handle",0
10     db      04h,"POST Results Bitmap",0
db      05h,"System Management Type",0
db      06h,"Multiple-Event System Management Type",0
dw      END_OF_ENUM_ID
dw      SET_REPEAT_END_ID
15     ; -----Repeating block end

```

#### **E. SET\_REPEAT\_START\_ID and SET\_REPEAT\_END\_ID**

These keys are used to indicate the start and ending fields in a repeat loop. When the utility program finds a SET\_REPEAT\_START\_ID key, it will mark the offset within the SMBIOS structure and return to it when it encounters a SET\_REPEAT\_END\_ID until the repeat count is exhausted.

##### Encoded Value:

```

SET_REPEAT_START_ID  0xFFE4
SET_REPEAT_END_ID    0xFFE5

```

##### Format:

```

dw      SET_REPEAT_START_ID
or
dw      SET_REPEAT_END_ID

```

##### Assembler Data Example:

These control keys are illustrated above with regard to SET\_REPEAT\_COUNT\_ID and SET\_REPEAT\_SIZE\_ID.

Many modifications and other embodiments of the invention will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.